ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. 5-12, SEATING DESIGN AND PLACING IN RELATION TO FATIGUE

Subject: Seat Design for M4 Tanks

Project No. 5-12

INFORMATION COPY

March 5, 1943

ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 5-12
749.2-12 GNOML

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SEAT DESIGN FOR M4 TANKS

1. PROJECT: Seating Design and Placing in Relation to Fatigue.

a. Authority: Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose: To apply anthropometric data representative of Armored Force personnel to seat design and location and to establish optimum and acceptable specifications.

2. DISCUSSION:

a. Physiological needs and general efficiency of tank crews are best served by seats which provide for safety, reasonable comfort, relaxation and natural accessibility to controls and visual devices. In order to establish the design and requirements for height adjustment of seats in the various crew positions, knowledge of the size, reach, sitting height, etc. of the occupants is necessary (See Fig. A). From this information the posture and placement of the man may be visualized and from this visual picture the man's comfort and susceptibility to fatigue can be appraised within limits.

b. Test procedure. Relevant anthropometric data (previously reported) were studied in relation to seat position and adjustments in the M4 tanks. Modified seats were installed in tanks for test and also set up in the Laboratory for study. Discussions were held with seat manufacturers to determine the practicability of changes that were indicated.

3. CONCLUSIONS:

a. The driver's and assistant driver's seats in the M4 tanks do not possess sufficient adjustment of height to allow efficient use of the periscope when the seats are in the low position. The lack of head room and the slumped posture required to use the periscope are conducive to fatigue.

b. The gunner's seat is adjustable through the required range to insure comfortable, efficient use of the periscope.

c. The commander's and loader's seats, being fixed, are satisfactory only for a very limited percentage of Armored Force personnel.

d. Excessive play and lack of sturdiness are largely responsible for unnecessary vibration and early failure of the adjusting mechanism in existing adjustable seats.

e. Improper or excessive application of paint causes difficulty in adjustment and operation of many seats.

f. Turret seats are too small to provide proper support and interfere with circulation in the legs.

g. Back-rests or padding are desirable on all turret seats to protect men from contact with metal.

4. RECOMMENDATIONS:

Provide seats for M4 tank personnel to meet the following requirements of design and construction:

a. Driver and assistant driver.*

1. Vertical adjustment. A total excursion of 13" with a major shift of 10" from the up to the down position and with further independent adjustment of height in four (4) one-inch increments, as described in Appendix A and Fig. D.

2. Horizontal adjustment. Fore and aft adjustment, as in the present seats.

3. Seat shape. Bucket-type padded seat, conforming in general to the design shown in Fig. E.

4. Back. Easily removable.

5. Floor mounting. Provide for the easy removal without special tools of the assistant driver's seat from its floor mounting, in order to afford quick access to the escape hatch.

b. Gunner:

1. Vertical adjustment. Retain the present range of vertical adjustment.

2. Back. Provide a removable, single-column back rest similar to the back on a stenographer's chair.

(* If the bow M.G. is to be equipped with a direct sight, seating for the assistant driver will have to be modified or the position of the M.G. changed. Exact data in the requirements are being obtained.)

- 2 -

c. *Commander:*

1. Vertical adjustment. Provide vertical adjustment in the lower seat through four (4) one-inch increments, the upper seat to remain, as now, in a fixed position.

2. Shape and size. Provide seats in the shape of a reversed D, with the broad dimension at the free end, (as in M7 tank) and as large as possible consistent with spatial limitations and with the necessity for folding out of the way when not in use.

3. Back rest. Provide a back rest or pad to prevent direct contact with metal.

4. Step formed when upper seat is folded. Make this as narrow as possible and round the corners to eliminate protrusion which strikes the commander's chest when he is using the periscope in certain positions.

d. Loader:

1. Vertical adjustment. Provide vertical adjustment through four (4) one-inch increments.

2. Shape and size. The same design requirements as outlined above for the commander's seat.

3. Back rest. Provide a back rest or pad to prevent direct contact with metal.

e. General Specifications:

1. Sturdiness. Seats and adjusting mechanism to be sturdily constructed and free from excessive vertical or horizontal play.

2. Materials for seat and back padding. To be of maximum resilience and minimum thermal conductivity and non-inflammable.

3. Painting. In the specifications to the first supplier include proper requirements with respect to painting that will insure free and smooth movement of the adjusting elements and permit only touch-up painting thereafter.

Submitted by:

Lester B. Roberts,
Captain, Sanitary Corps.

18 Incls.
1 - Appendix A
2 - Figs A thru E
3 - Curves A thru L

APPROVED Willard Machle
WILLARD MACHLE,
Lieut. Col., Medical Corps,
Commanding.

Figures B, C, and D graphically represent the seat positions and excursions necessary to accommodate Armored Force personnel. From these data recommendations with respect to position and vertical excursion can be determined. The points considered are; comfort, efficient use of periscope, optimum viewing from seat-up position, adequate head room with helmet on, and ability to relax by change from normal slumped position to erect sitting posture.

A complete view through the periscope is possible only when the eyes are at a level with the center line of the periscope window. Slight deviations from this position are not serious for general viewing but the level is critical for efficient use of the telescope in the gunner's periscope. In the seat-up position there is also an optimum eye level which allows maximum view of the terrain ahead. Since the driver and assistant driver may remain in either the seat-up or seat-down position for extended periods it is desirable that they be able to adjust themselves in a natural position at either level. This requires small increments of seat adjustment at both the seat-up and seat-down positions (to place the eyes at the desired levels). Fig. B illustrates the excursions required in the seat-down position for personnel having various eye-head measurements in combination with the full range of sitting heights. Head clearances with 1½ inch helmet are also included. Although the data are not yet available to establish a definite relationship, it is reasonable to assume that a usable correlation exists between eye-head distance and sitting height. Such a direct correlation has been assumed in Fig. C and on the basis of this assumption the vertical adjustment required at the low position is materially reduced. Fig. D combines the requirements, assuming the above correlation, for both the seat-up and seat-down positions. From this figure the eye height, head clearance, slump, etc. of any percentage of Armored Force personnel can be determined. For example, with the existing seat at its lowest position (A in Fig. D) only the shorter 27% of the Armored Force population have head room with helmets on. The remaining 73% must slump forward and are unable to sit erect. Ten percent of the men with maximum sitting height must slump a minimum of 2½ inches at all times and as much as 4 to 6 inches in order to place the eye at periscope level. In the upper position, however, the adjustment in the existing seat is adequate for the entire population for outside viewing either when erect or with the usual 1½ inch slump.

The proposed seat (See Fig. D) has two independent adjusting mechanisms, one for the major shift of 10 inches from seat-up to seat-down position, and the second for fine adjustment in four (4) one-inch increments when the seat is in either the up or down position. With this arrangement it should be necessary for the individual to make his height adjustment only once. Assuming his posture at both positions to

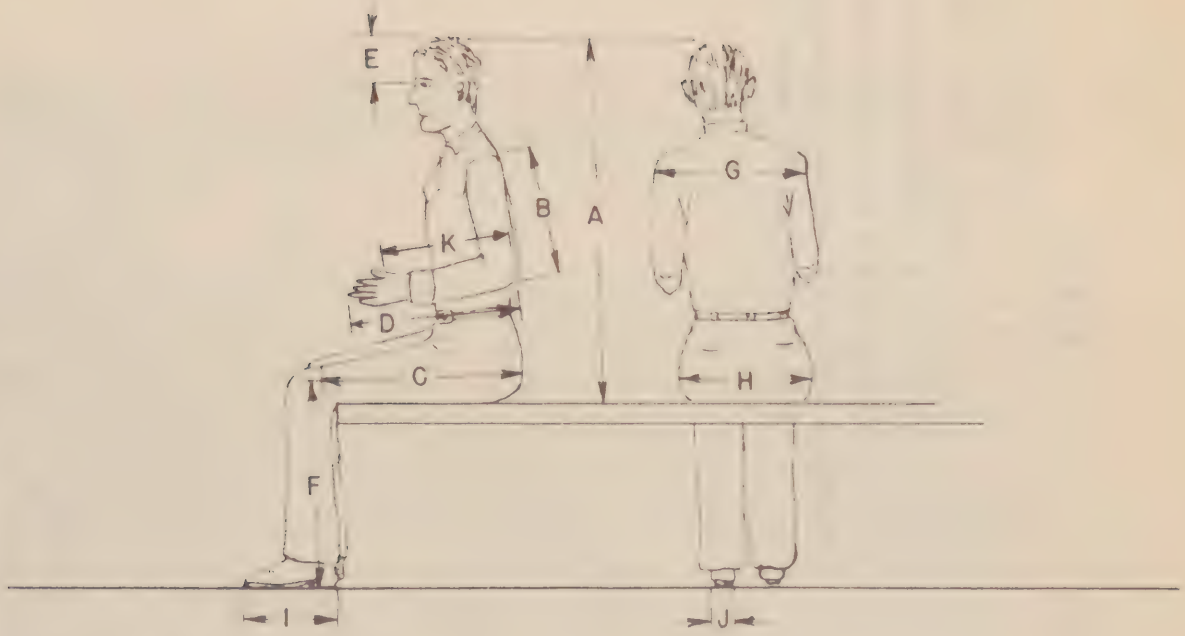
be the same, only the major shift of 10 inches would be necessary to change from one optimum eye level to the other. A sketch of such a seat mechanism is shown in Fig. E. This sketch shows a bucket-type seat which is believed to have definite advantages. If seats of the same basic design are provided for the driver and assistant driver, the latter seat must be mounted on a spacer welded to the tank floor to bring the seat to the proper level. The low position of the proposed seat will be 3" lower than the present seat and will thus permit sighting of the present bow machine gun at greater elevations than at present.

Seats of the type described will be tested when samples are received.

It may be possible to alter existing seats to cover more adequately the required range of height adjustment. As illustrated in Fig. D, this can be accomplished by reducing the height of the base of the seat 2¼ inches. It should be remembered, however, that these seats are far from satisfactory because of vibration and lack of sturdiness of adjusting mechanism.

The gunner's seat requires adjustment only through the range of variation in the sitting height of the population. The requirements for this, as well as any other seat from which periscopic viewing is employed, can be determined by measuring the distance from the center of the periscope window to the seat level. As the commander is generally seated directly behind the gunner and the back of the gunner's seat interferes with his leg room, it is recommended that that part of the seat and back interfering, be reduced so as to allow as much room for the commander's knees as possible. A stenographer's chair type back rest seems indicated. The back should be removable and capable of being folded forward onto the top of the seat.

In turret seats, where attached back rests may be impractical, it is recommended that special care be exercised in placing padding and that more padding be employed than usual to protect both against shock and contact with hot or cold metal.



		AVE."	MIN"	MAX"
A	SITTING HEIGHT	36.4	32.7	40.6
B	SHOULDER — ELBOW	14.7	10.6	16.9
C	BUTTOCK — KNEE	23.6	19.3	27.6
D	ELBOW — FINGER TIP	18.8	16.7	21.9
E	EYE — HEAD	4.4	3.4	5.7
F	PATELLA HEIGHT	22.0	18.1	25.6
G	BI-DELTOID	18.0	15.4	20.5
H	BI-TROCHANTERIC	14.02	11.8	18.5
I	G.I. SHOE LENGTH	11.7	10.1	13.5
J	G.I. SHOE WIDTH	4.2	3.7	4.6
K	ELBOW — GRIP	14.2	12.4	16.4

FIG. A

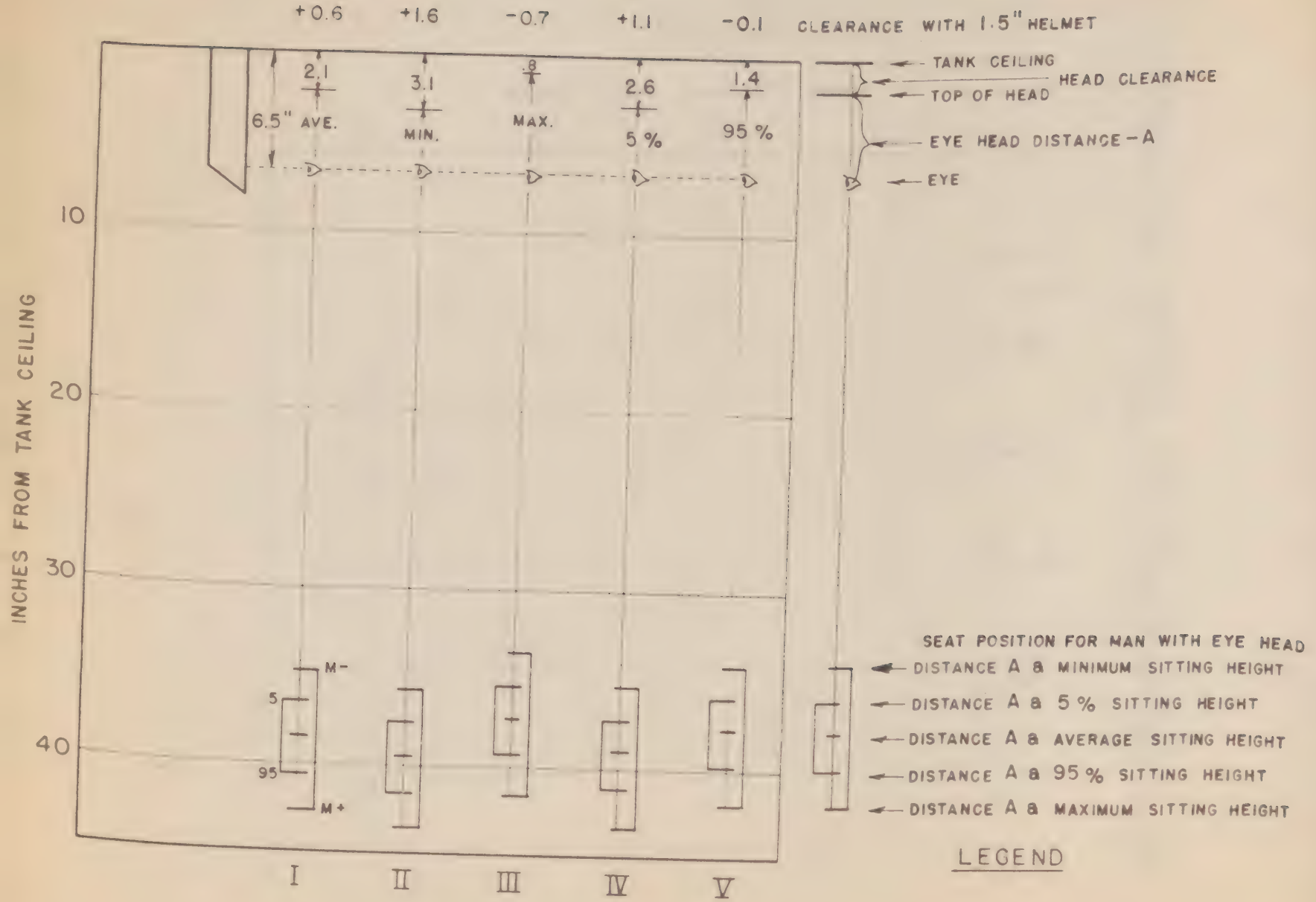

+0.6
+1.6
-0.7
+1.1
-0.1
CLEARANCE WITH 1.5" HELMET
TANK CEILING
HEAD CLEARANCE
TOP OF HEAD
EYE HEAD DISTANCE - A
EYE
2.1
6.5" AVE.
3.1
MIN.
.8
MAX.
2.6
5 %
1.4
95 %
INCHES FROM TANK CEILING
10
20
30
40
M-
5
95
M+
I
II
III
IV
V
SEAT POSITION FOR MAN WITH EYE HEAD
DISTANCE A @ MINIMUM SITTING HEIGHT
DISTANCE A @ 5 % SITTING HEIGHT
DISTANCE A @ AVERAGE SITTING HEIGHT
DISTANCE A @ 95 % SITTING HEIGHT
DISTANCE A @ MAXIMUM SITTING HEIGHT
LEGEND

Fig B

IF COORELATION BETWEEN EYE-HEAD & SITTING HEIGHT

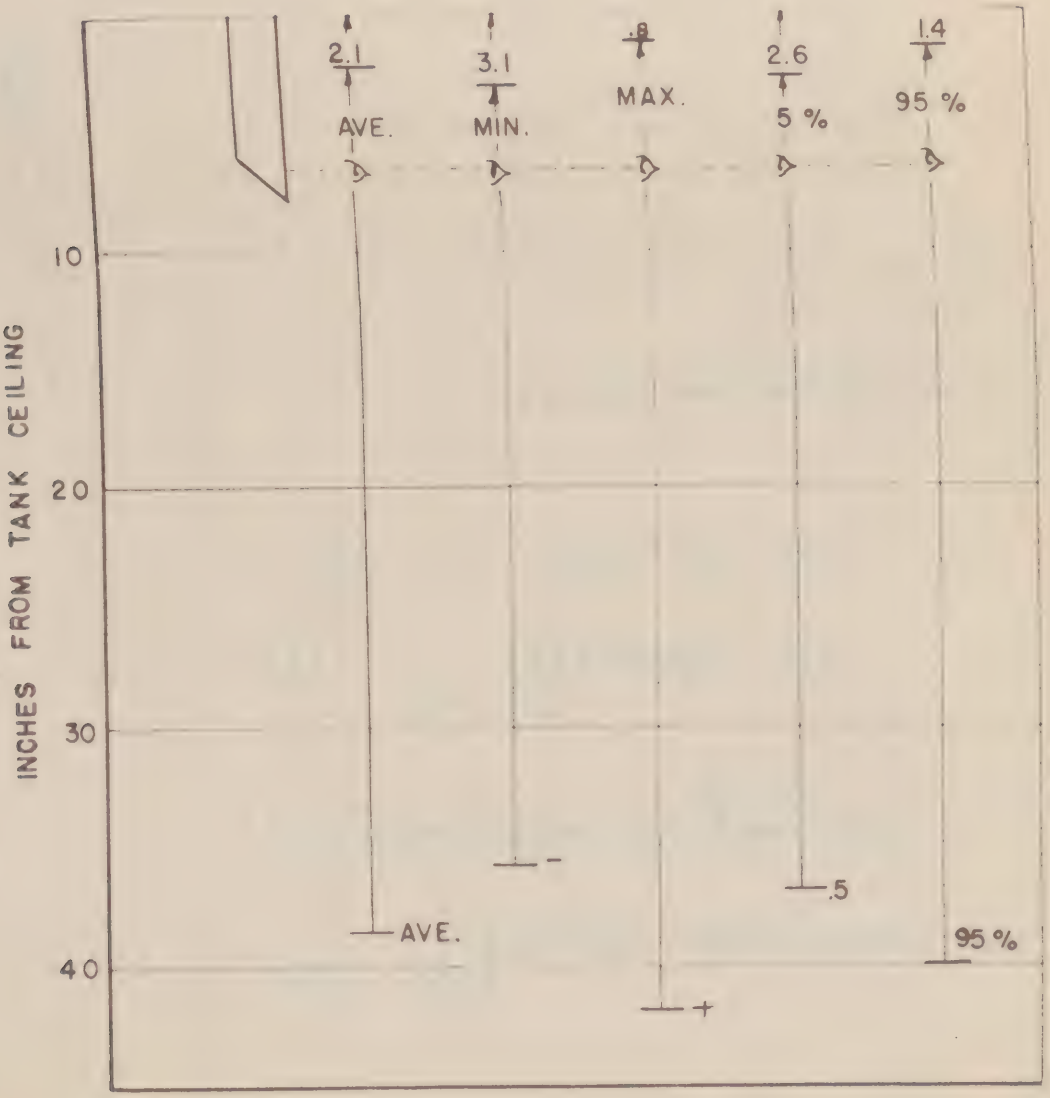


FIG. C

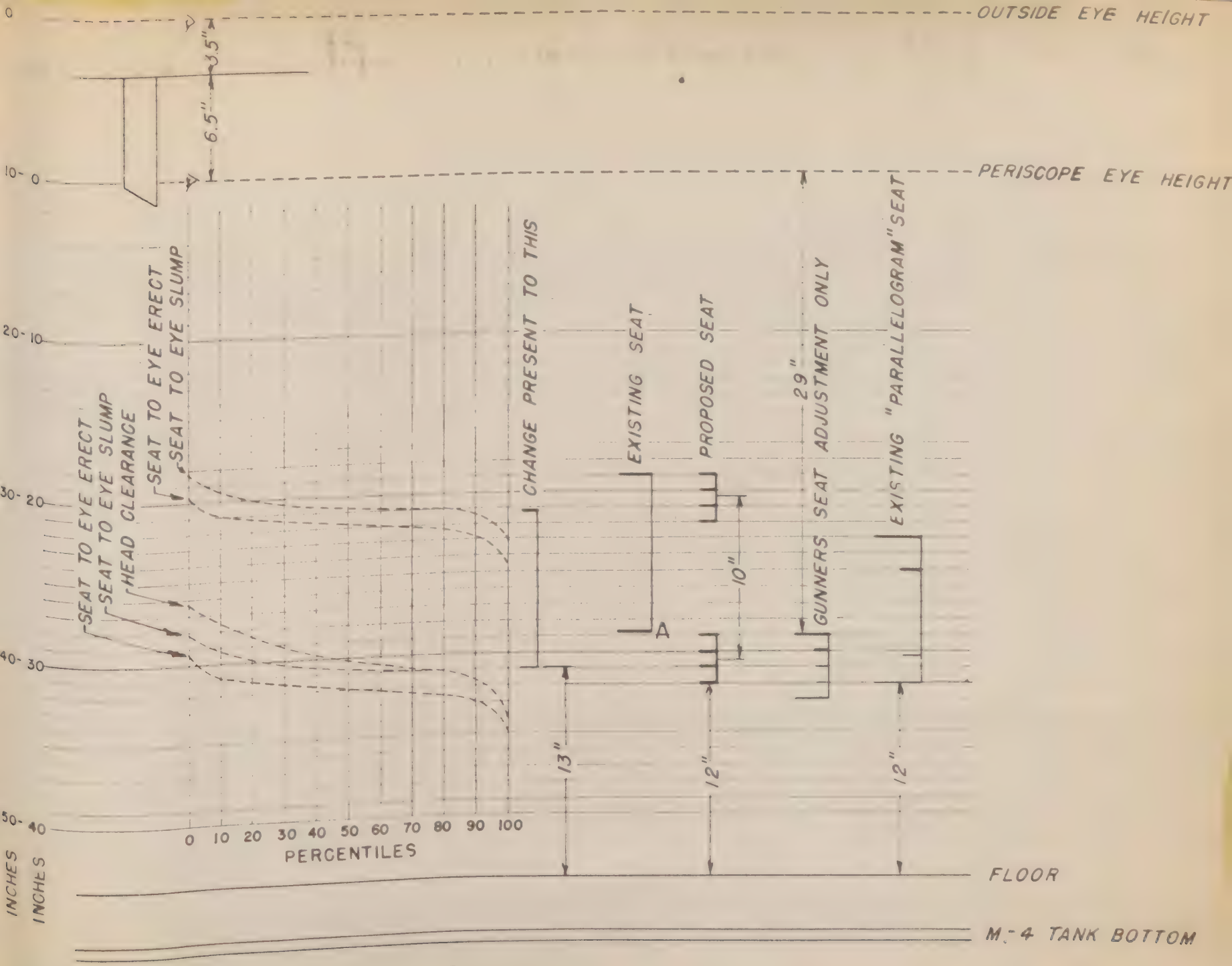

OUTSIDE EYE HEIGHT
3.5"
6.5"
PERISCOPE EYE HEIGHT
SEAT TO EYE ERECT
SEAT TO EYE SLUMP
HEAD CLEARANCE
SEAT TO EYE ERECT
SEAT TO EYE SLUMP
CHANGE PRESENT TO THIS
EXISTING SEAT
PROPOSED SEAT
29"
GUNNERS SEAT ADJUSTMENT ONLY
EXISTING "PARALLELOGRAM" SEAT
A
10"
13"
12"
12"
0 10 20 30 40 50 60 70 80 90 100
PERCENTILES
INCHES
INCHES
0
10
20
30
40
50
FLOOR
M-4 TANK BOTTOM

FIG. D

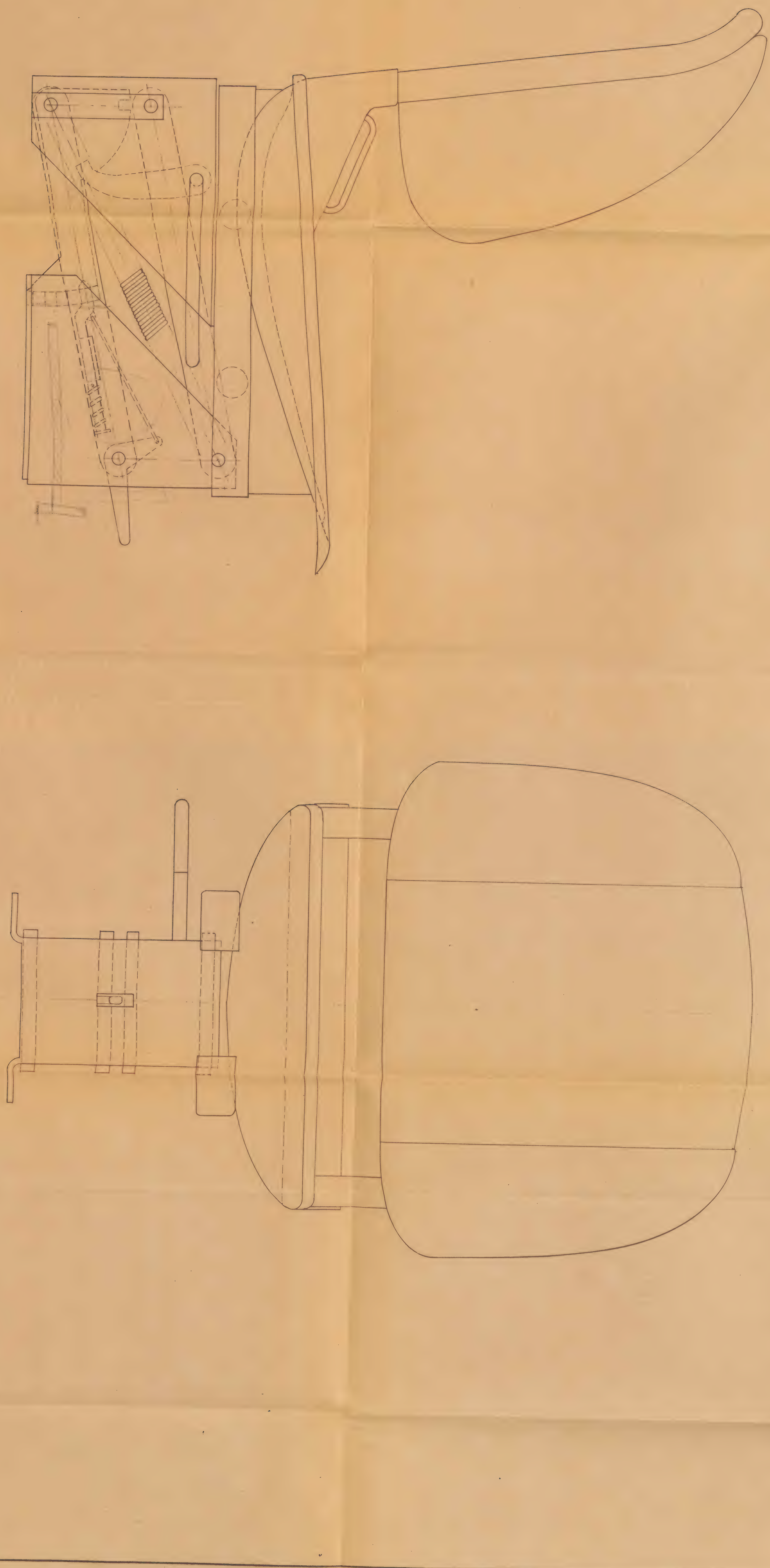
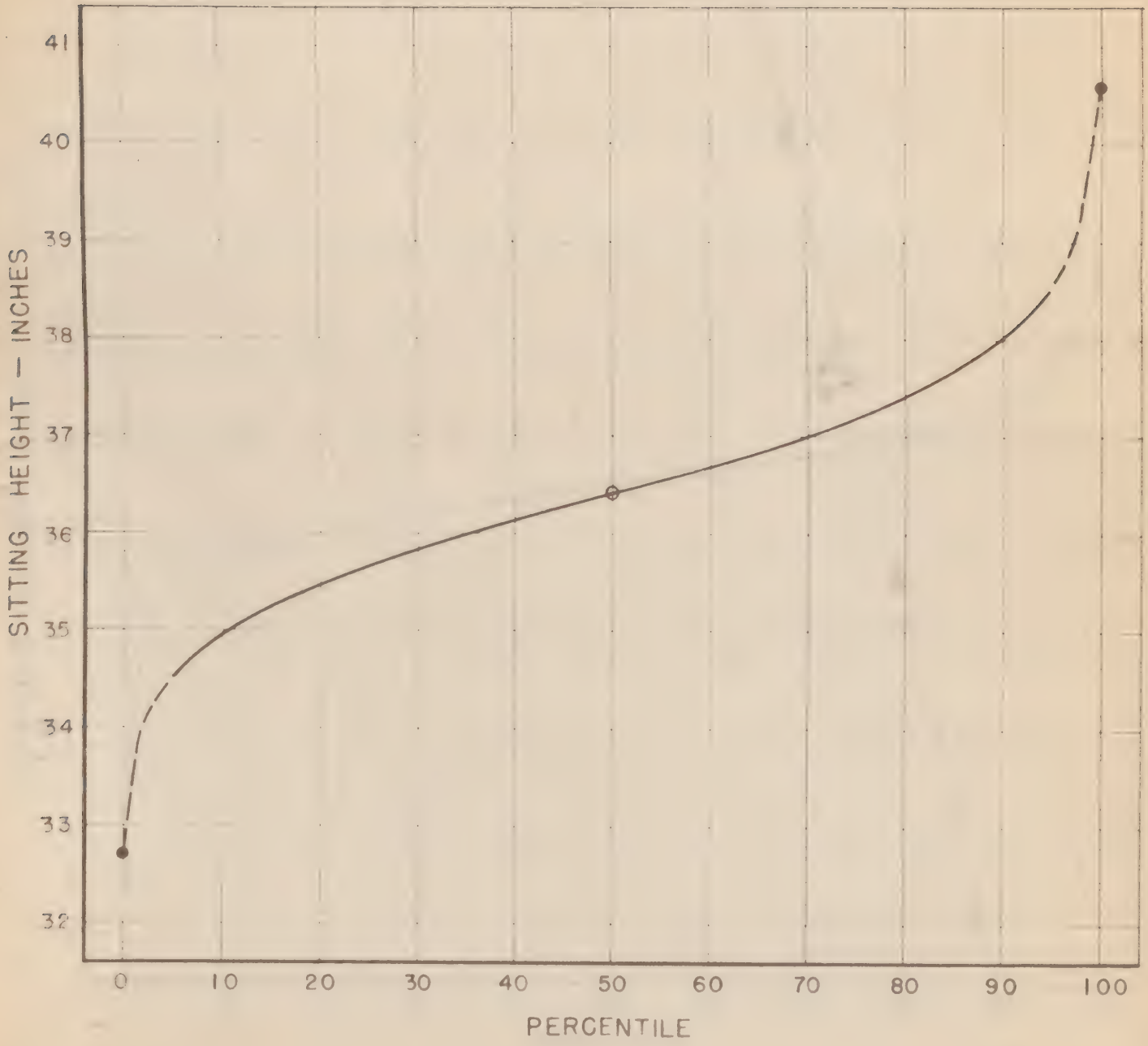
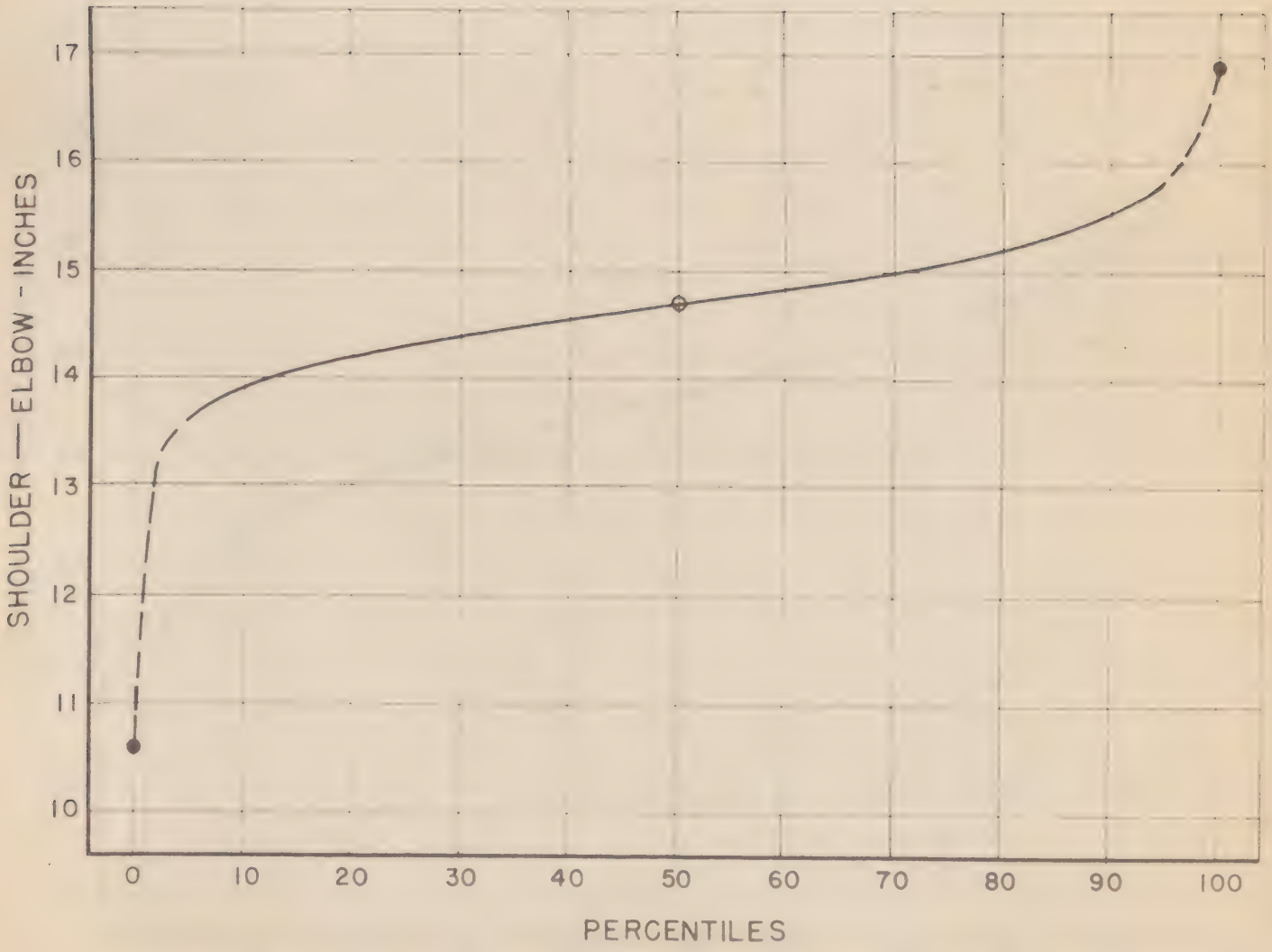


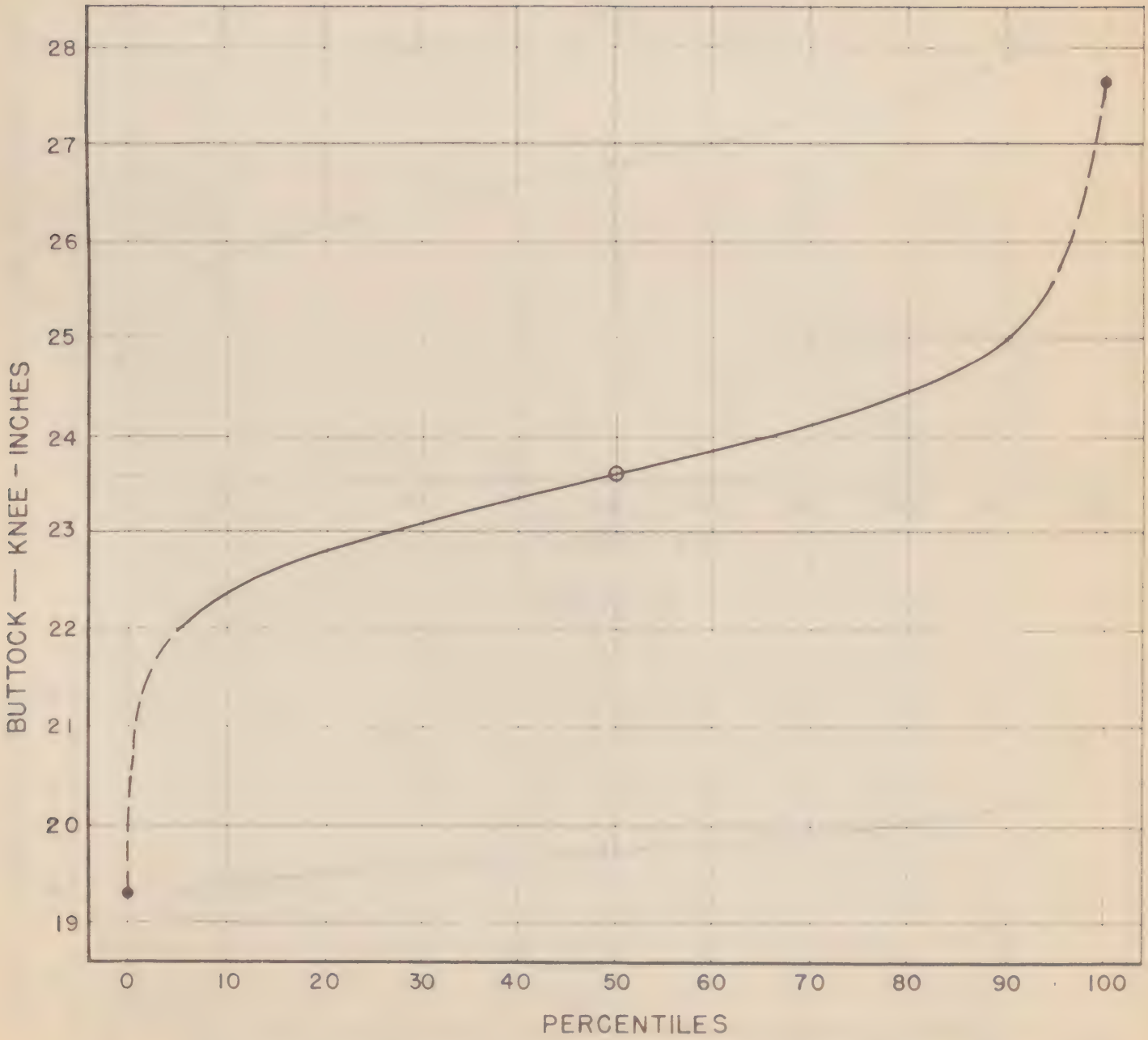
FIG. E


41
40
39
38
37
36
35
34
33
32
SITTING HEIGHT — INCHES
0
10
20
30
40
50
60
70
80
90
100
PERCENTILE

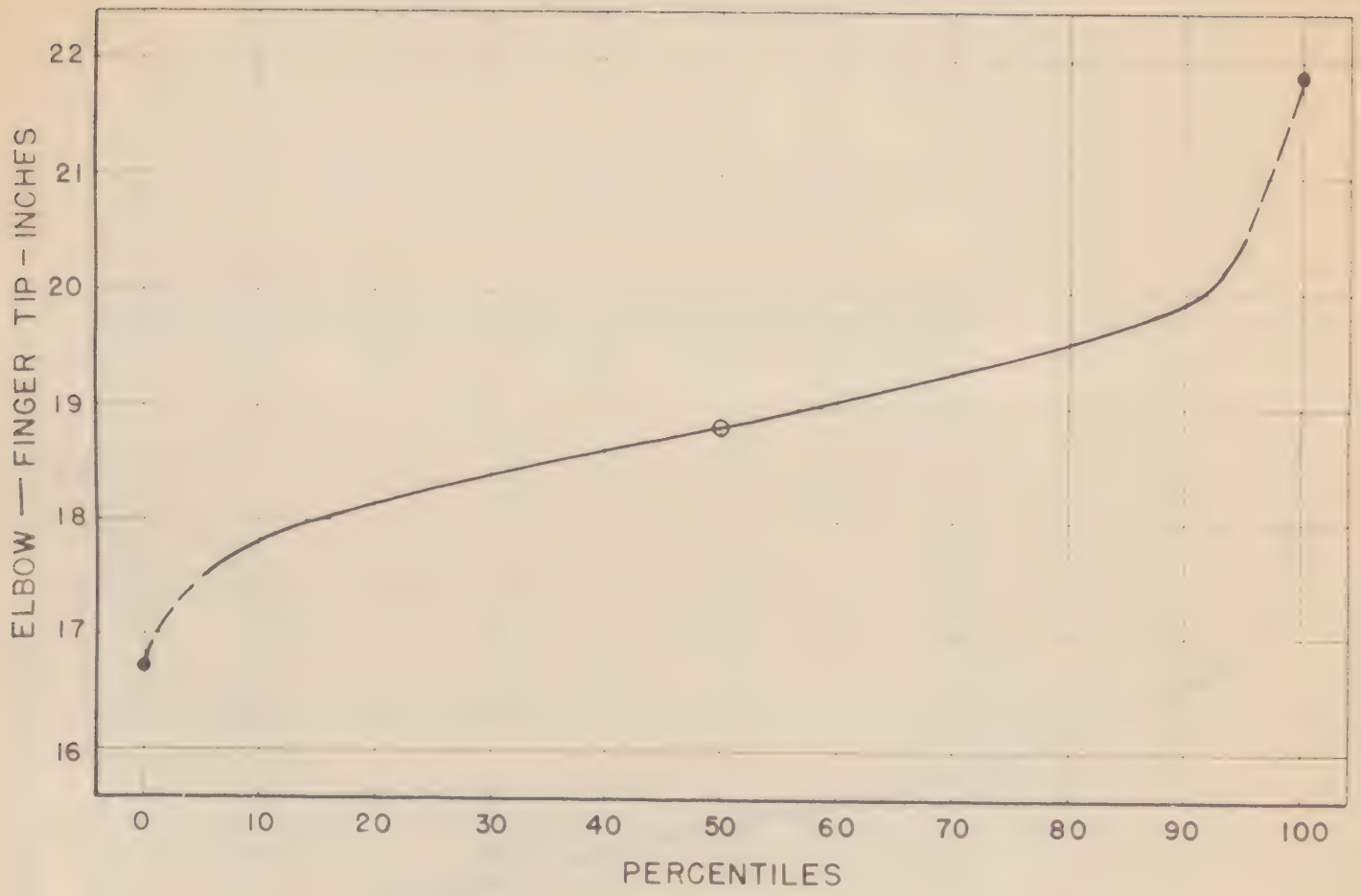
CURVE A


SHOULDER — ELBOW - INCHES
17
16
15
14
13
12
11
10
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

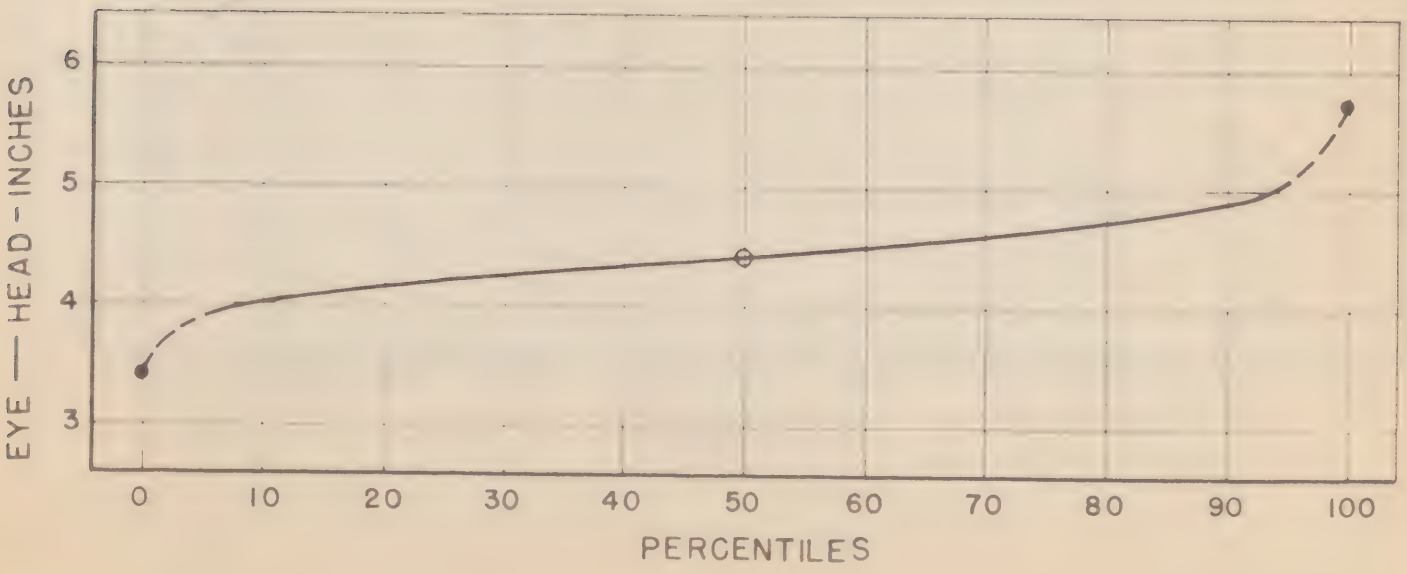
CURVE B


28
27
26
25
24
23
22
21
20
19
BUTTOCK — KNEE - INCHES
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

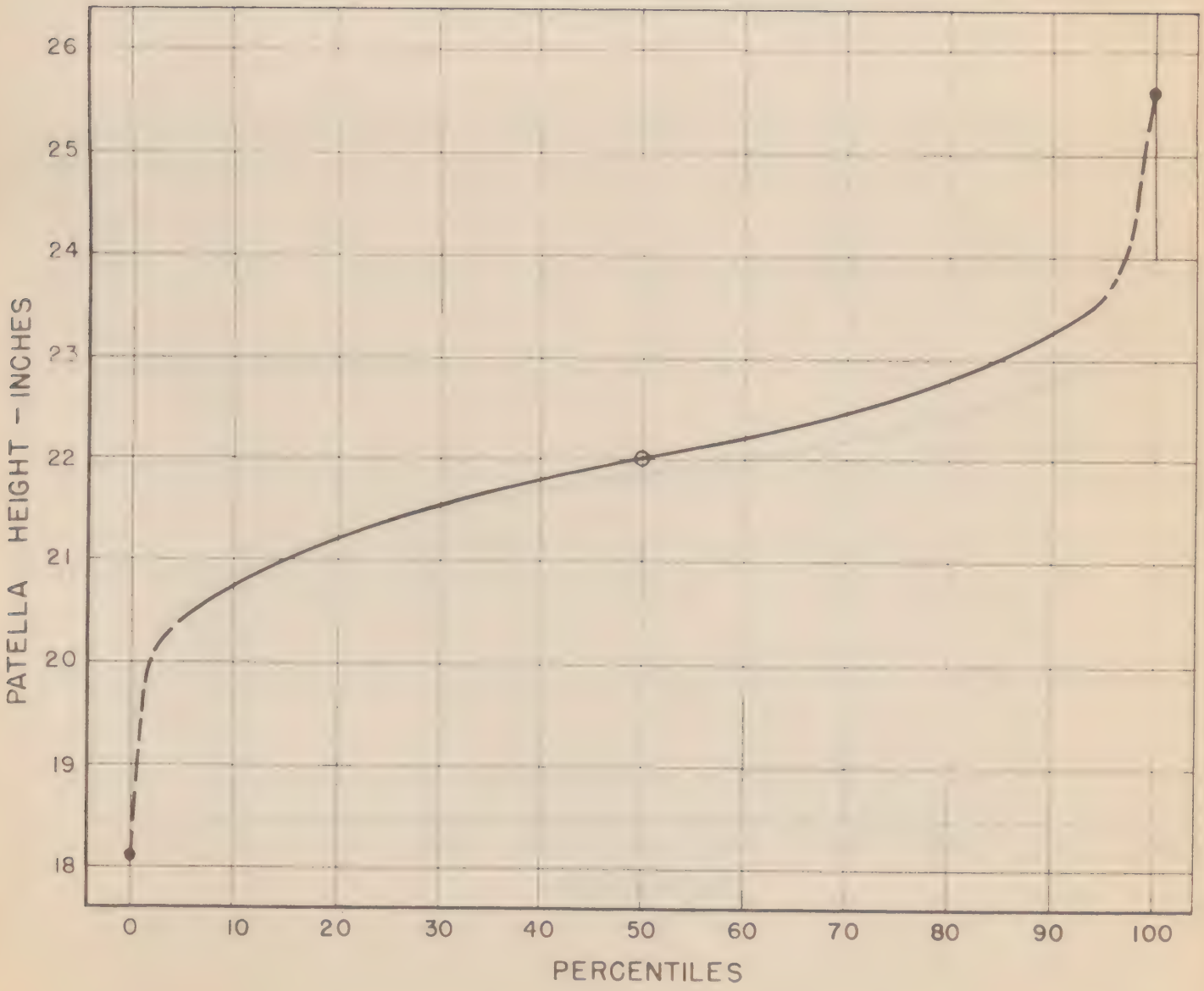
CURVE C



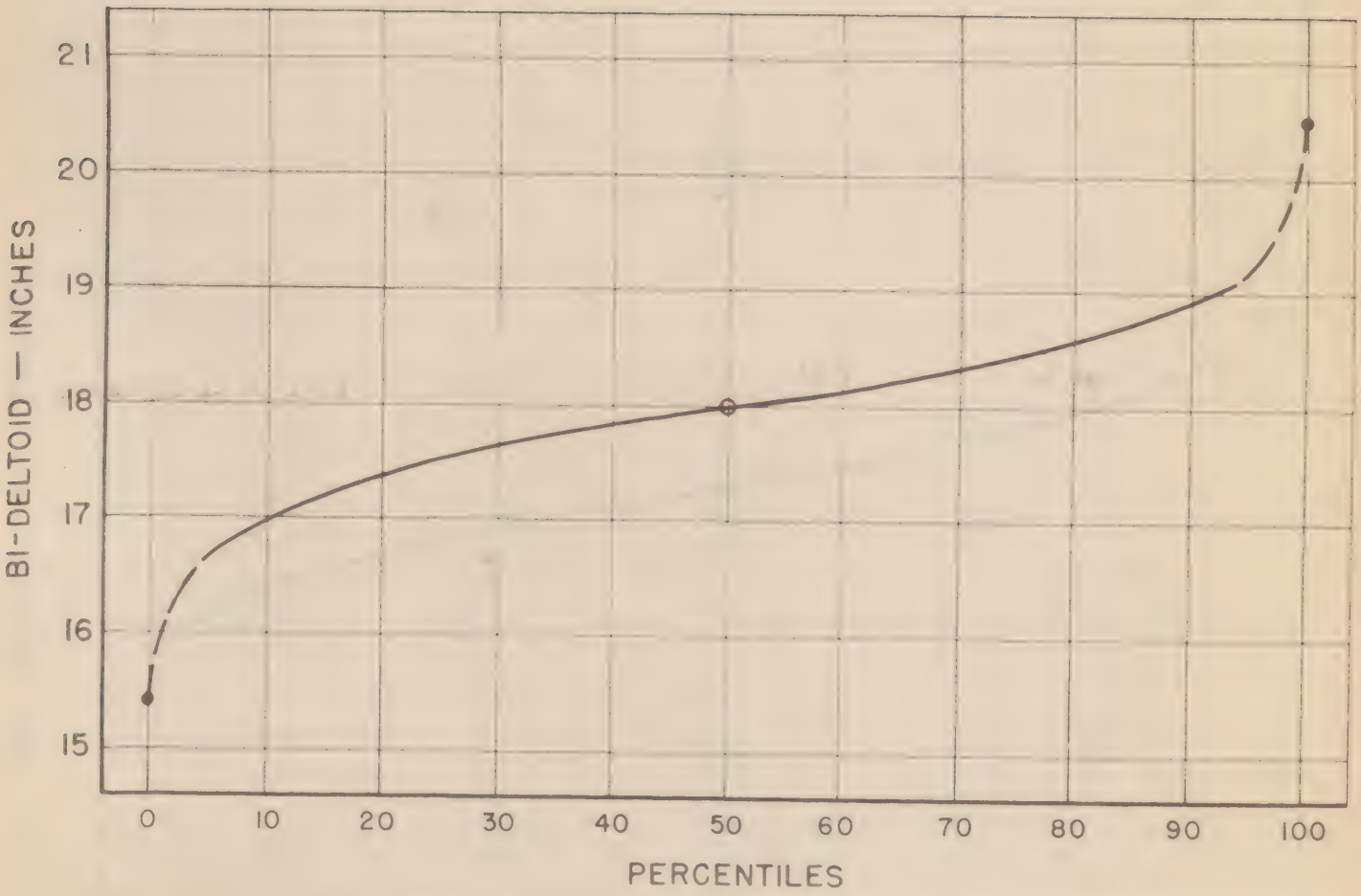
CURVE D



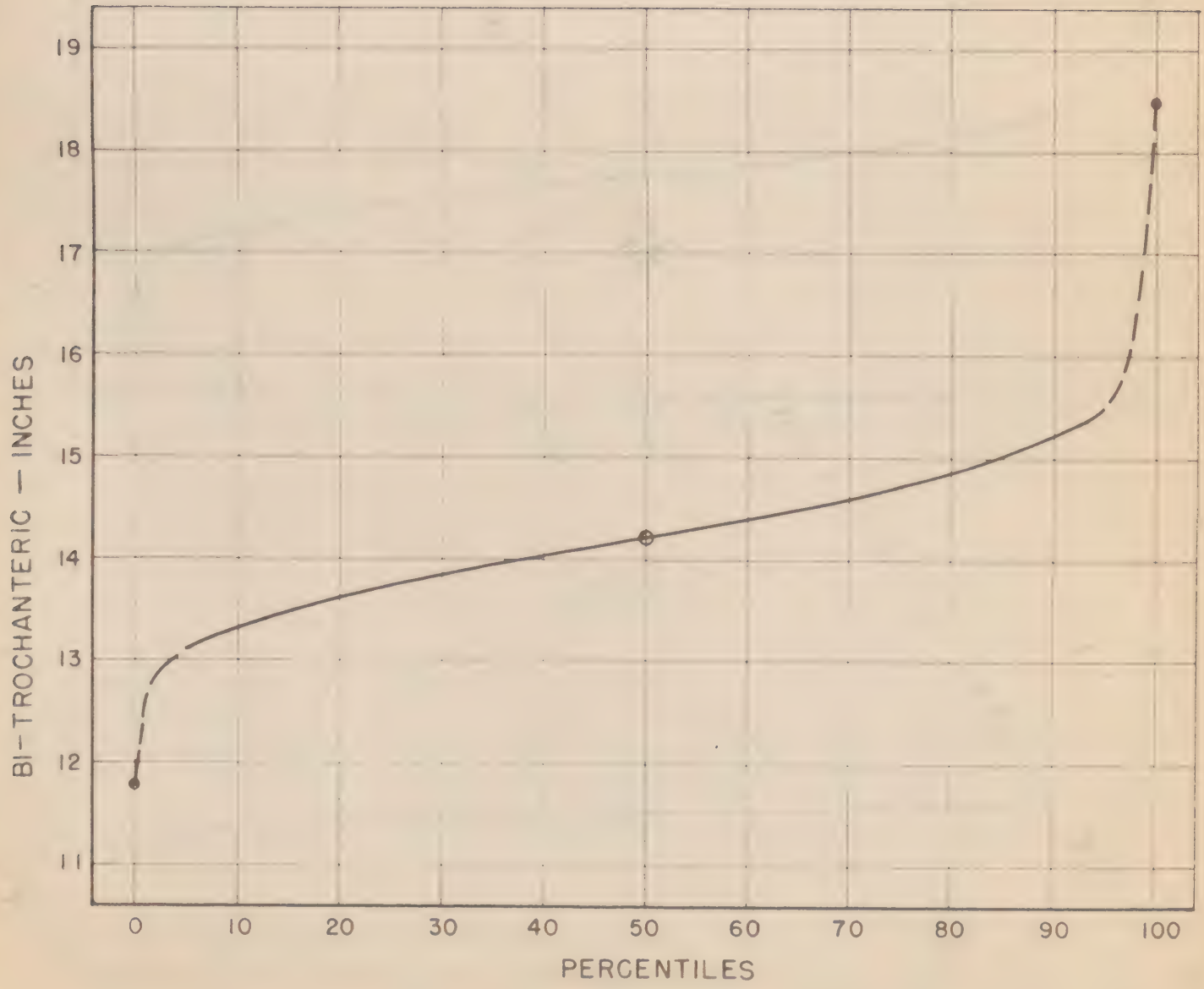
CURVE E


PATELLA HEIGHT - INCHES
26
25
24
23
22
21
20
19
18
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

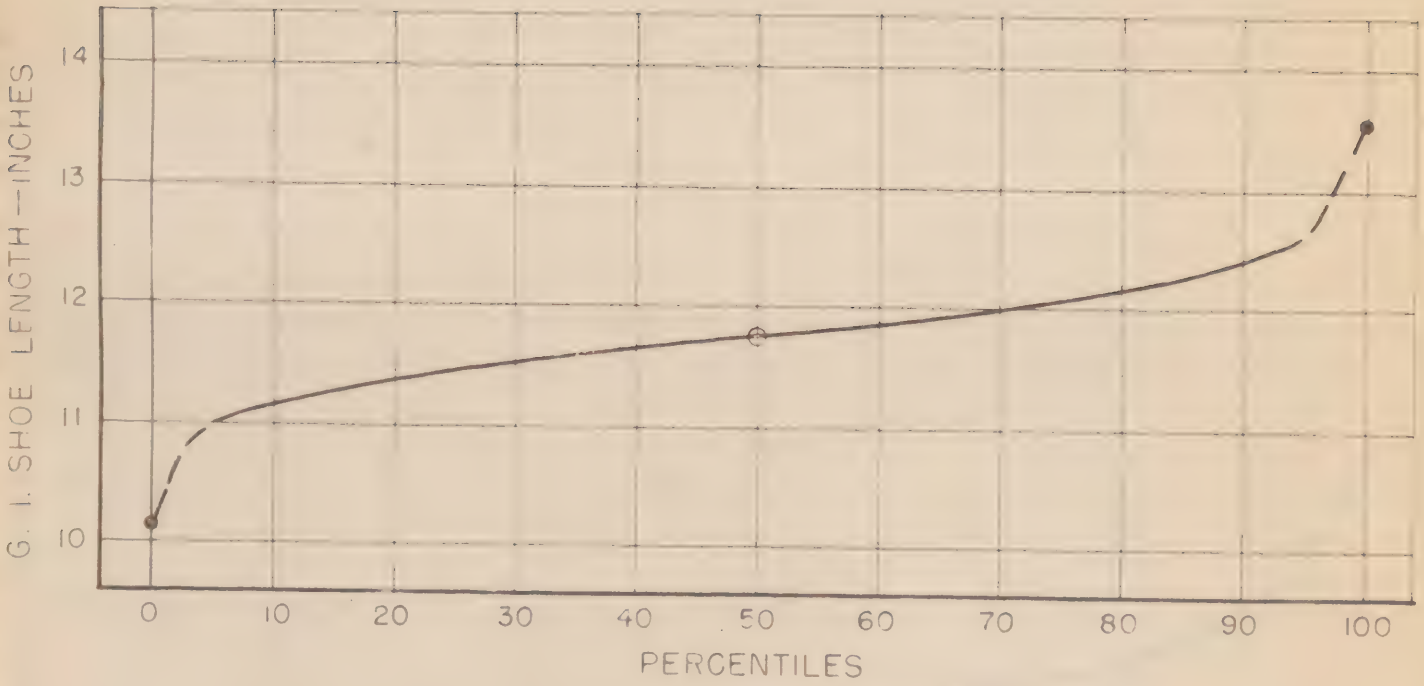
CURVE F


BI-DELTOID — INCHES
21
20
19
18
17
16
15
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

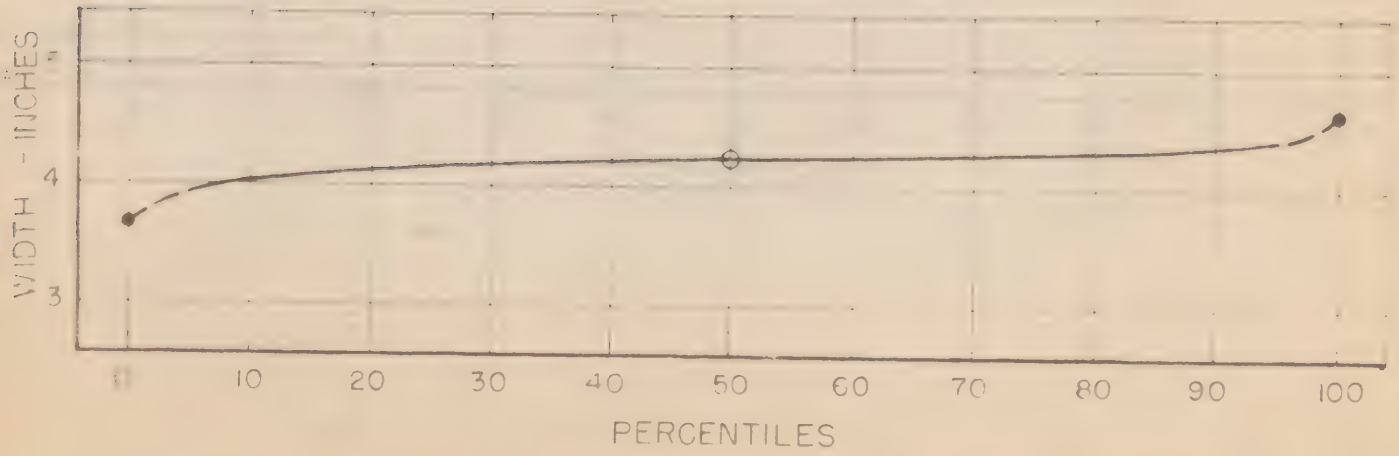
CURVE G


BI-TROCHANTERIC — INCHES
19
18
17
16
15
14
13
12
11
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

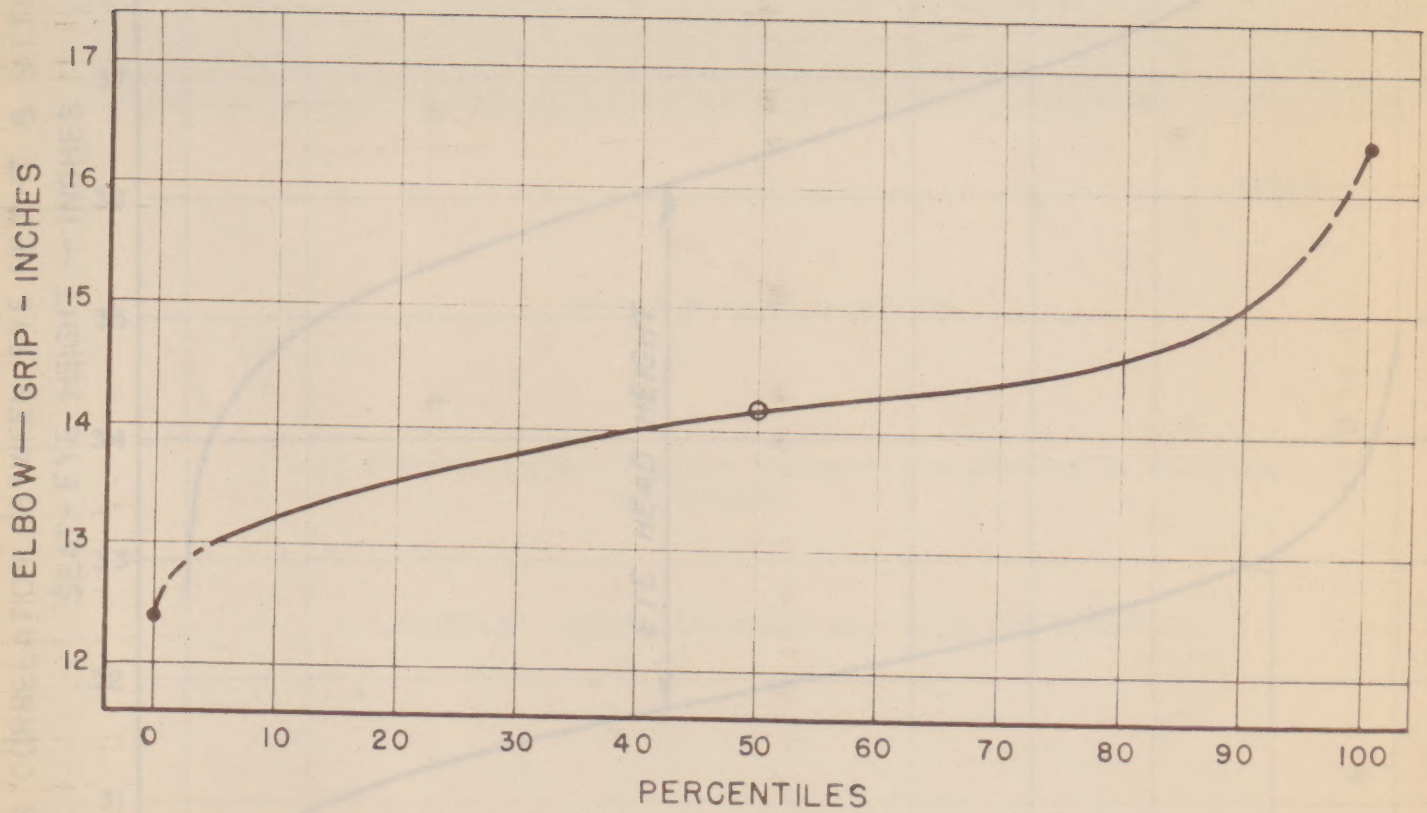
CURVE H



CURVE I

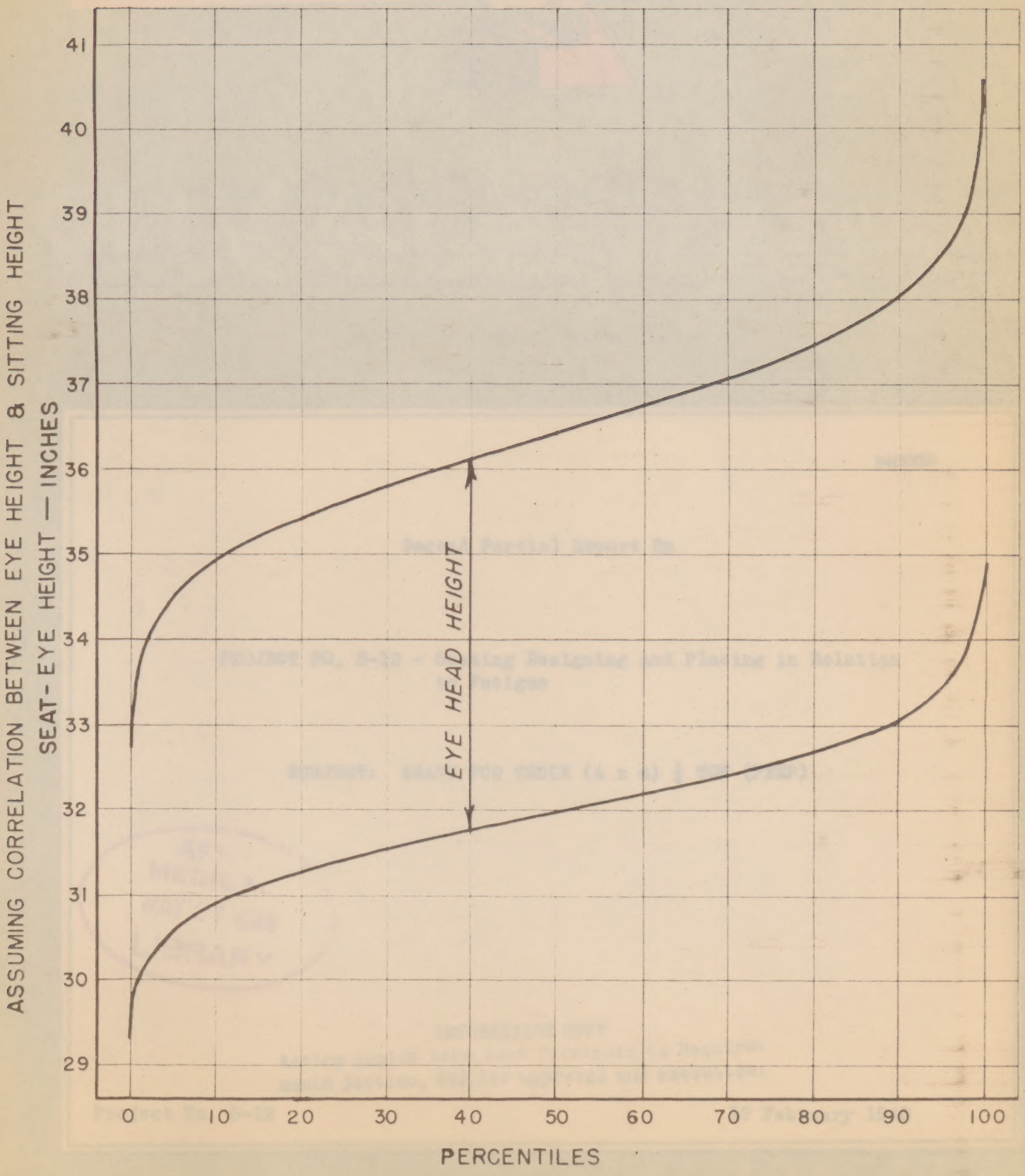


CURVE J


ELBOW — GRIP - INCHES
17
16
15
14
13
12
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

CURVE K

0
10
20
30
40
50
60
70
80
90
100
12
14
16
18


ASSUMING CORRELATION BETWEEN EYE HEIGHT & SITTING HEIGHT
SEAT - EYE HEIGHT — INCHES
41
40
39
38
37
36
35
34
33
32
31
30
29
EYE HEAD HEIGHT
0
10
20
30
40
50
60
70
80
90
100
PERCENTILES

CURVE L

EYE HEAD HEIGHT
THIGH